An Ink Cartridge

The invention relates to an ink cartridge.

A first known ink cartridge comprises an ink tank with an ink supply outlet and an air vent, the ink tank being filled with a porous member saturated with ink. The capillary action of the porous member inhibits leakage of ink through the ink supply outlet or air vent.

A second known ink cartridge is disclosed in EP-A-0581531. This known ink cartridge comprises an ink tank with a first chamber and a second chamber separated by a partition, the partition terminating above the floor of the tank to provide a gap forming a communication port for fluid communication between the two chambers. The cartridge also has an air vent and an ink supply outlet, both of which are in the wall of the first chamber. A porous member fills the first chamber. There is no porous member in the second chamber, which forms an open volume for storage of ink.

In use of the known two chamber ink cartridge disclosed in EP-A-0581531, as ink is withdrawn through the ink supply outlet to feed the print head of a printer, air is drawn in through the air vent and the ink level in the first chamber drops. When the level of ink has dropped to the point where the ink boundary in the porous member intersects the communication port, air will start to enter the second chamber through the communication port as further ink is withdrawn. In this way, the ink in the second chamber is used.

The advantage of the known two chamber cartridge of EP EP-A-0581531 over the known single chamber cartridge described above is that it has a greater ink capacity. In the single chamber cartridge, the porous member occupies the whole of the ink tank and takes up a certain volume. By providing the partition in the second known cartridge, the second chamber is formed which does not have any outlets to atmosphere hence need not be occupied by a porous member. The whole of the second chamber can be

occupied by ink, so that, in spite of the presence of the partition, the ink capacity of the cartridge as a whole is increased.

A disadvantage of the known two chamber cartridge over the known single chamber cartridge however is in the situation of decreased atmospheric pressure or increased temperature. As described, as the ink is withdrawn from the cartridge, a volume of air enters the second chamber. If atmospheric pressure decreases or the temperature increases, the volume of air trapped above the ink in the second chamber will expand and exert a pressure on the ink which can lead to leakage of ink through the ink outlet port, and hence from the print head of the printer in which the cartridge is situated, or can lead to poor quality printing.

According to one aspect of the invention there is provided an ink cartridge comprising an ink tank, the ink tank comprising a first chamber, the cartridge including an air vent and an ink supply outlet both opening into the first chamber the cartridge further including means defining a volume in which air and ink can collect to form a buffer against expansion or contraction of ink and air in the first chamber to prevent leakage from the cartridge.

The ink cartridge preferably includes a second chamber connected for fluid communication with the first chamber preferably at a low level.

The cartridge preferably includes a passage from the first chamber to the second chamber.

According to another aspect of the invention there is provided an ink cartridge comprising an ink tank, the ink tank comprising first and second chambers connected for fluid communication at a low level, the cartridge including an air vent and an ink supply outlet, the air vent and ink supply outlet both opening into the first chamber, characterised in that the cartridge further includes means defining a passage from the first chamber to the second chamber, the entrance to the passage from the first chamber being at a higher level than the exit from the passage into the second chamber.

As the ink in the cartridge of the invention is withdrawn through the ink supply outlet, the ink level in the first chamber will drop until air enters the passage. As more ink is withdrawn, the passage will fill with air and air will start to enter the second chamber. If at that point there is a decrease in ambient pressure or an increase in temperature, the air in the second chamber will expand exerting pressure on the ink below it. The ink will move back along the passage in response to the pressure and in this way the passage acts as a buffer by allowing the ink to rise and fall in a controlled manner. The potential problem of leakage through the ink outlet port and hence from the print head is thus avoided.

A capillary active member may cover the fluid communication connection between the first and second chambers. A capillary active member may cover the entrance to the passage. A capillary active member may block the ink supply outlet. Preferably, a capillary active member or negative pressure producing member is provided in the first chamber and covers at least one of the fluid communication connection between the first and second chambers, the entrance to the passage and the ink supply outlet. Preferably, a capillary active member or negative pressure producing member is provided in the first chamber and covers the fluid communication connection between the first and second chambers and the ink supply outlet. A capillary active member may be provided in the first chamber and may cover the ink supply outlet and the entrance to the passage.

The passage may contain a negative pressure producing member, but preferably the passage is an open volume.

The passage may be of any suitable shape and may extend in any suitable direction. In a preferred embodiment, part of the passage is above the entrance to the passage from the first chamber. Air can thus rise into the passage. The passage may conveniently extend above the second chamber.

The exit from the passage into the second chamber may be on the far side of the second chamber from the first chamber.

Indeed, according to another aspect of the invention there is a provided an ink cartridge comprising an ink tank, the ink tank comprising first and second chambers connected for fluid communication at a low level, the cartridge including an air vent and an ink supply outlet, the air vent and ink supply outlet both opening into the first chamber, characterised in that the cartridge further includes means defining a passage from the first chamber to the second chamber, the exit from the passage into the second chamber being on the far side of the second chamber from the first chamber.

The passage preferably extends upwardly from the entrance thereto. In a preferred embodiment, the passage forms a volume in which air can collect. The passage thus preferably includes a part which is above the entrance to the passage from the first chamber and also preferably above the exit from the passage into the second chamber.

According to a further aspect of the invention there is provided an ink cartridge comprising an ink tank, the ink tank comprising first and second chambers connected for fluid communication at a low level, the cartridge including an air vent and an ink supply outlet, the air vent and ink supply outlet both opening into the first chamber, characterised in that the cartridge further includes means defining a passage or third chamber from the first chamber to the second chamber, the passage or third chamber including a part defining a volume in which air can collect, the volume defined by the part being above the entrance to the passage or third chamber from the first chamber and above the exit from the passage or third chamber into the second chamber.

In a particularly preferred embodiment, the passage extends over the top of the second chamber and down the opposite side of the second chamber from the first chamber to the exit into the second chamber.

The wall of the second chamber may define at least part of one side of the passage. The outer wall of the tank may define at least part of one side of the passage.

The second chamber may include at least one partition, the partition having an aperture at a low level. The aperture may be below the level of the passage exit into the second

chamber. In this way, the volume of trapped air can be reduced because the second chamber is divided.

The passage exit is preferably above the level of, or at the same level, as the connection between the first and second chambers.

Two embodiments of the invention will now be described by way of example and with reference to the accompanying drawings.

Figures 1 to 9 each show a side elevation of the main part of the cartridge in the first embodiment with different indications of ink level;

Figure 10 is a perspective view of the main part of the cartridge shown in Figures 1 to 9;

Figure 11 is a perspective view of the other part of the cartridge of the first embodiment; and

Figures 12 to 23 each show a side elevation of the main part of the cartridge in the second embodiment of the invention with different indications of ink level.

The cartridge 10 of the first embodiment of the invention is made in two parts 6, 8.

The main part 6 of the cartridge 10 is generally tray shaped. The other part 8 of the cartridge 10 is generally flat and rectangular with a peg 4 at each corner to be received in circular recesses 11 defined in the main part 6 of the cartridge 10.

The cartridge 10 of the first embodiment comprises an ink tank 12 with an ink supply outlet tube 14 and an air vent 16.

The ink tank 12 contains a number of internal walls. First internal wall 18 depends from the top of the tank 12 to a level about three quarters of the way down into the

cartridge. The wall 18 does not quite reach the top 20 of the ink tank 12. Another wall 22 just below the top 20 of the ink tank 12 extends from the top of the wall 18 to the end 24 of the ink tank 12. A third wall 26 extends upwardly from adjacent the floor 28 of the ink tank 12 parallel to the end wall 24 and turns through 90° to run parallel to the second wall 22 before turning through 90° again to run down parallel to the first wall 18 before turning through 90° to extend until it is directly beneath the first wall 18, then turning downwards over a short distance to terminate above the floor 28 of the ink tank 12. The two ends 30, 32 of the wall 26 are at about the same height. A passage 33 is defined between the wall 26 and the first wall 18, second wall 22 and end wall 24. The passage 33 is of constant cross section.

A first chamber 34 is defined on the other side of the first wall 18 from the wall 26, and the wall 26 together with the floor 28 of the ink tank 12 defines a second chamber 36. The second chamber 36 is divided by a central divider 38 which depends from the wall 26 vertically down to adjacent the floor 27 half way between the two upright sections of the wall 26. The lower end 40 of the wall 38 terminates above the floor 28 at a level lower than the ends 30, 32 of the wall 26.

The second chamber 36 and the passage 33 constitute open volumes. Two porous members 42, 44 occupy the first chamber 34.

The air vent 16 opens into the first chamber 34 at the top of the first chamber 34 and leads into a space 46 formed above a horizontal rib 48 which extends from the end wall 50 (opposite the end wall 24).

The first porous member 42 is an open cell foam material such as urethane and extends from the top of the first chamber 34 to a level just above the lower end 52 of the first wall 18.

The second porous member 44 has a lower pore size than the first porous member 42 and may be made of an extruded fibrous material, the fibres having no particular orientation overall.

The ink supply outlet 14 extends from the floor 28 of the ink tank 12 and leads out of the first chamber 34. A filter layer 54 is bonded to the lower side of the second porous member 44. The second porous member 44 is sized such that it fills the space in the first chamber 34 beneath the first porous member 42 with the filter layer 54 lying on the floor 28 in the first chamber 34 of the ink tank 12 over the ink supply outlet port 14. The second porous member 44 thus covers the gap 56 between the end of the wall 26 and the floor 28 which is the communication port between the first and second chambers 34, 36. The second porous member 44 also covers the entrance 58 to the passage 33, namely, the gap between the lower end 52 of the first wall 18 and the part of the wall 36 is directly below it. The second porous member 44 together with the filter layer 54 also covers the entirety of the upper end of the ink supply outlet port 14.

Each internal wall 18, 22, 26, 38 is mainly defined in the main part 6, but short walls 18a, 22a, 26a and 38a are formed on the other part 8 of the cartridge 10 and the two parts of the walls fit together.

In use, the cartridge 10 is fitted into a printer [not shown].so that the ink withdrawal needle [not shown] of the printer is received in the ink supply outlet port 14 for withdrawal of ink from the cartridge 10 for supply to the print head of the printer. The printer may be an ink jet printer.

Figures 1 to 7 show how ink is withdrawn from the cartridge 10 of the first embodiment of the invention.

Figure 1 shows a new, unused cartridge. The second chamber 36 and the passage 33 are full of ink, the second porous member 44 is saturated with ink and the first porous member 42 is substantially saturated with ink, the ink level 60 being close to the top of the first porous member 42.

As ink is withdrawn from the cartridge 10 for printing at the print head of the printer, air enters through the air vent 16 and the ink level in the first chamber 34 drops as shown in Figure 2. At this point, the ink level 60 is still in the first porous member 42,

in other words above the entrance 58 to the passage. Ink cannot come out of the second chamber 36 or the passage 33 at this level, because air could not enter the passage or the second chamber 36 to replace the ink. The ink level therefore only falls in the first chamber 34 which is vented by the air vent 16.

Once the ink level 60 intersects the entrance 58 to the passage, air from the first chamber 34 can bubble into the passage 33 through the entrance 58 as shown in Figure 3 and a pocket of air 62 forms at the top of the passage 33.

As ink continues to be withdrawn through the ink supply outlet port 14, air continues to enter the passage 33 to replace the ink which is withdrawn until the passage 33 has filled with air as shown in Fig. 4. As further ink is withdrawn, air will then bubble beneath the lower end 30 of the wall 26 through the exit 64 from the passage 33 into the first sub-chamber 66 of the second chamber 36.

As further ink is withdrawn from the cartridge 10 for printing at the print head of the printer, air will continue to pass from the air vent 16 through the first porous member 42 and the second porous member 44 into the entrance 58 of the passage 33, along the passage 33 and through the exit 64 from the passage 33 into the first sub-chamber 66 of the second chamber 36 to form a pocket 68 of trapped air at the top of the first sub-chamber 66 as shown in Fig. 5. It will be noted that in this stage of emptying of the cartridge, the high capillarity of the second, lower porous member 44 resists movement of ink out of the second porous member 44 such that ink is taken preferentially from the open volume constituted by the passage 33 and the second chamber 36.

As ink continues to be withdrawn from the cartridge, the level of ink 70 will drop until it reaches the lower end 40 of the divider 38 at which point air will begin to bubble into the second sub-chamber 72 of the second chamber 66 as shown in Fig. 6. Because the lower end 30 of the wall 26 at the exit from the passages above the height of the lower end 40 of the divider 38, the first sub-chamber 66 of the second chamber 36 is now in air communication with the passage 33 and thereby through the first chamber 34 to the air vent 16 and atmosphere.

As ink is withdrawn from the cartridge 10, the second sub-chamber 72 will fill with air and empty of ink in the same way as the first chamber 66. Once the ink level reaches the lower end 32 of the wall 26 forming the communication port between the first and second chambers 34, 36, ink will continue to be withdrawn from the second chamber 36 into the lower, second porous member 44 because of the capillarity of the second porous member 44. The second chamber 36 can therefore be completely or almost completely emptied so that finally the only ink remaining in the cartridge 10 is in the second porous member 44, as shown in Figure 7. The printer may be arranged to stop drawing ink from the cartridge before the cartridge is emptied of ink.

It is thus seen that in the cartridge 10 of the embodiment, the passage 33 and the second chamber 36 represent open volumes for ink storage, increasing the capacity of the cartridge, and that these volumes can be effectively emptied such that they represent an efficient way of storing ink in a cartridge of a given size.

Returning now to Figure 5, in which there is a pocket of air 68 at the top of the first sub-chamber 66, but the level of ink 74 is above the exit 64 from the passage 33. If when the cartridge is in that condition, there is a decrease in atmospheric pressure, or an increase in temperature, then the air in the cartridge will expand. The air in the first chamber 34 can escape through the air vent 16. Likewise the air in the passage 33 can expand into the first chamber 34 through the passage entrance 58 and pressure can be relieved through leakage through the air vent 16. The pocket of air 68 is trapped however and as it expands it will exert pressure on the ink below it. The movement of the ink is shown in Figure 8 where the original level of the ink 74, 76 is shown as a dotted line and the level of ink 78, 80 after movement is shown as a solid line. As the air in the air pocket 68 expands, the ink level 74 in the first sub-chamber 66 drops to the level 78. In consequence, ink moves back up the passage so that the ink level rises from 76 to 80 in the passage 33 to compensate for the movement of ink in the first sub-chamber 66. In this way, the passage 33 acts as a buffer, allowing the ink to rise and fall in a controlled manner as the trapped air expands or contracts. This prevents the ink from being forced into the second porous member 44 from which it might travel to the print head causing leakage or dripping at the print head. It is seen that, in entering the passage 33 the ink is faced with an open volume to occupy, rather than the

tortuous volume represented by the high capillary second porous member 44, and so the passage 33 forms a preferential route for movement of the ink.

Figure 9 shows the situation where there is a pocket of air 82 trapped at the top of the second sub-chamber 72. If there is a decrease in atmospheric pressure, or an increase in ambient temperature, then the air in the pocket 82 will expand exerting pressure on the ink below it so that the ink level 84 will drop in the second sub-chamber 72 from the level shown by the dotted line to the level shown by the solid line, while the ink level to the other side of the divider 38 rises from the dotted line to the solid line 86. At the level of expansion shown in Figure 9, the increase in the height of the ink level to the other side of the divider 38 does not yet intercept the lower end 30 of the wall 26 at the exit 64 from the passage. If the ink level should be pushed further so that it intercepts the end 30 of the wall 26, then air will be trapped above the ink in the first sub-chamber 66 and any further expansion will be taken up by movement of ink back up the passage 33.

In an alternative embodiment, the divider 38 need not be provided. This does mean however that the volume of air that can be trapped at any one time is larger than with the divided chamber so that the consequent volume expansion and therefore movement of ink along the passage will be of greater magnitude compared with the embodiment with the divided chamber. Equally, two or more dividers 38 may be provided. It will be appreciated that each divider should preferably terminate at a lower level than the end of the wall 30 defining the upper edge of the exit from the passage, and also at a lower level than the preceding divider. This will reduce the volume of air that can be trapped at any one time, but each divider occupies a volume which could otherwise be occupied by ink, so the ink capacity of the cartridge is reduced.

In an alternative embodiment, the first and second porous members 42, 44 of the first embodiment may be replaced by a single porous member of constant porosity. The use of two porous members of different porosity as in the embodiment described in relation to the drawings however results in better emptying of the cartridge as the higher

capillarity of the second porous member will draw ink out of the lower porosity of the first porous member 42.

The embodiment of Figs. 12 to 23 will now be described. This embodiment is similar to the embodiment of Figs. 1 to 11 and only the differences from that embodiment will be described. The same reference numerals will be used for equivalent features.

The passage 33 of this embodiment does not extend over the top of the second chamber 36 and there is no divider 38 in the second chamber 36. The wall 26 also does not include the kink towards the lower end 32. The lower end 32 of the wall 26 lies adjacent but spaced from the floor 28 leaving a communication gap 56 as before, although the gap 56 is smaller as the lower end 32 of the wall 26 is closer to the floor 28 in this embodiment.

The wall 26 includes an aperture 90. The aperture 90 is above the level of the lower end 52 of the wall 18, but is closer to that level than to the top of the passage 33. Indeed the aperture 90 is only slightly above the level of the lower end 52 of the wall 18.

Figures 12 to 20 show how ink is withdrawn from the cartridge 10 of this embodiment of the invention.

Figure 12 shows a new, unused cartridge. The second chamber 36 and the passage 33 are full of ink, the second porous member 44 is saturated with ink and the first porous member 42 is substantially saturated with ink, the ink level 60 being close to the top of the first porous member 42.

As ink is withdrawn from the cartridge 10 for printing at the print head of the printer, air enters through the air vent 16 and the ink level 60 in the first chamber 34 drops as shown in Figure 13. At this point, the ink level 60 is still in the first porous member 42, in other words above the entrance to the passage 33 defined by the lower end 52 of the wall 18. Ink cannot come out of the second chamber 36 or the passage 33 at this level,

because air could not enter the passage 33 or the second chamber 36 to replace the ink. The ink level therefore only falls in the first chamber 34 which is vented by the air vent 16.

Once the ink level 60 intersects the lower end 52 of the wall 18, air from the first chamber 34 can bubble into the passage 33 past the lower end 52 of the wall 18 as shown in Figure 14 and a pocket of air 92 forms at the top of the passage 33, as shown in Figure 15.

As ink continues to be withdrawn through the ink supply outlet port 14, air continues to enter the passage 33 to replace the ink which is withdrawn until the ink level in the passage 33 intersects the top wall 94 defining the aperture 90 as shown in Fig. 16. As further ink is withdrawn, air will then bubble through the aperture 90 into the second chamber 36.

As further ink is withdrawn from the cartridge 10 for printing at the print head of the printer, air will continue to pass from the air vent 16 through the first porous member 42 and the second porous member 44 into the passage 33, and thence through the aperture 90 from the passage 33 into the second chamber 36 to form a pocket 96 of trapped air at the top of the second chamber 36 as shown in Fig. 17. It will be noted that in this stage of emptying the cartridge, the high capillarity of the second, lower porous member 44 resists movement of ink out of the second porous member 44 such that ink is taken preferentially from the open volume constituted by the passage 33 and the second chamber 36.

As ink continues to be withdrawn from the cartridge 10, the level of ink 70 will continue to drop, and when the ink level reaches the lower wall 98 defining the lower side of the aperture 90, the ink level to either side of the wall 26 will become the same, as shown in Fig. 18, as the passage 33 and the upper part of the second chamber 36 are in air communication.

As ink is withdrawn from the cartridge 10, the ink level will continue to fall as shown in Fig. 19. Once the ink level reaches the lower end 32 of the wall 26 forming the

communication port 56 between the first and second chambers 34, 36, ink will continue to be withdrawn from the second chamber 36 into the lower, second porous member 44 because of the capillarity of the second porous member 44. The second chamber 36 can therefore be completely or almost completely emptied so that finally the only ink remaining in the cartridge 10 is in the second porous member 44, as shown in Figure 20. The printer may be arranged to stop drawing ink from the cartridge before the cartridge is emptied of ink.

It is thus seen that in the cartridge 10 of the embodiment of Figures 12 to 23, the passage 33 and the second chamber 36 represent open volumes for ink storage, increasing the capacity of the cartridge, and that these volumes can be effectively emptied such that they represent an efficient way of storing ink in a cartridge of a given size.

Returning now to Figure 17, in which there is a pocket of air 96 at the top of the second chamber 36, but the level of ink 100 is above the upper wall 94 of the aperture 90 to the passage 33. If when the cartridge 10 is in that condition, there is a decrease in atmospheric pressure, or an increase in temperature, then the air in the cartridge will expand. The air in the first chamber 34 can escape through the air vent 16. The air in the passage 33 will expand driving the ink level 102 in the passage 33 down but the ink level 102 will meet the upper wall 94 of the aperture 90 and so the excess air will bubble into the second chamber 36 as shown. The pocket of air 96 is trapped and as it expands it will exert pressure on the ink below it. The movement of the ink is shown in Figure 21 where the original level of the ink 100 is shown as a dotted line and the level of ink 78, 80 after movement is shown as a solid line. As the air in the air pocket 68 expands and air enters from the passage 33, the ink level 100 in the second chamber 36 drops to the level 104. In consequence, ink is moved back into the second porous member 44 and first porous member 42.

Figures 22 and 23 show the situation where ambient temperature decreases or atmospheric pressure increases. In this situation, the air in the passage 33 and second chamber 36 contracts so that the ink level 102, 100 rises to new levels 106, 108 shown

in solid lines in Figure 22. As a result, the ink level in the first chamber 34 drops and so air bubbles from the first chamber 34 into the passage 33 as shown in Figure 22. If the ambient temperature decrease or atmospheric pressure increase is of sufficient magnitude, then the air bubbling into the passage 33 will cause the ink level 106 there to fall to the level of the top wall 94 of the aperture 90 and air will bubble through the aperture 90 into the second chamber 36.